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Sir:

Enclosed herewith for filing is the following utility patent application:

Applicant: Cheng Guo and Stephen Moffatt
Title of Application: METHODS FOR FABRICATING LITHOGRAPHY APPARATUS
Pages Of Specification: 19 Sheets of Drawing: 17
Executed on: October 27, 2000 Docket No.: AMAT 5264

PATENT APPLICATION FILING FEE CALCULATION

| | <u>No. Filed</u> | <u>Less</u> | <u>Rate/Claim</u> | <u>Fee</u> |
|-----------------------|------------------|-------------|-------------------|-------------|
| Total Claims | 46 | -20 | x \$18.00 | \$ 468 0.00 |
| Independent Claims | 7 | -3 | x \$80.00 | \$ 320.00 |
| | | | | \$ 788.00 |
| | | | Basic Filing Fee | \$ 710.00 |
| Assignment..... | | | | \$1,498.00 |
| Total Filing Fee..... | | | | \$ 40.00 |
| | | | | \$1,538.00 |

Please charge Deposit Account No. 50-1074/4084 the amount of \$1,498.00 for the filing fee and \$40 for the recordation of the assignment. (A duplicate copy of this transmittal is enclosed.)

The Commissioner is hereby authorized to charge payment of any additional fees required under 37 CFR 1.16 and/or any patent application processing fees under 37 CFR 1.17 associated with this communication, or credit any overpayment, to Deposit Account No. 50-1074/48084.

The Commissioner is hereby authorized to charge payment of any filing fees under 37 CFR 1.16 for presentation of extra claims and/or any patent application processing fees under 37 CFR 1.17 during the pendency of this application, or credit any overpayment, to Deposit Account No. 50-1074/48084.

Also enclosed herewith for filing in connection with the enclosed application are:

Declaration and Power of Attorney;
An Information Disclosure Statement
Form PTO-1449
Form PTO-1595;
An Assignment of the Application; and
Postcard

METHODS FOR FABRICATING LITHOGRAPHY APPARATUSCross-Reference to Related Applications

This application is related to U.S. Serial No. ,
entitled "Methods For Fabricating Stencil Masks", which
5 has a common assignee and one common inventor and is
being filed concurrently with this application.

Field of the Invention

This invention relates to lithography, and more
particularly, to masks used in lithography and mask
10 support structures and their preparation.

Background of the Invention

As the size of electronic components used in
integrated circuits has shrunk and their density in
circuits increased, there has been growing interest in
15 electron beam lithography. In electron beam lithography,
an electron beam is used to write patterns on an electron
beam resist layer formed over a top surface of the
semiconductor wafer that is the workpiece for the
electron beam lithography. A particular form of electron
20 beam lithography of special interest for the invention is
described as **Scattering With Angular Limiting Projection**
Electron Beam Lithography ("Scalpel").

Scalpel is an electron beam lithography technique
that typically has employed masks in which the mask used
25 for control in the irradiation of the workpiece has been
formed as a thin patterned coating supported on a thin
membrane. Scalpel has been described in various
publications.

The requirements for such a membrane-mask
30 combination are quite demanding. Typically, it needs to
be planar, relatively easy to make, and comparatively
rugged. A particular problem has been the forming of the
membrane that is to support the coating in which the mask
pattern is formed. The membrane needs to be of
35 relatively large area, typically at least several inches
on a side, to be practical for use in large scale
manufacture. It needs also to be very thin, typically no
thicker than about 1000 Angstroms in thickness, to permit

electrons that pass through the mask to penetrate it easily without excessive scattering or experiencing excessive loss in electron beam energy. Moreover, it also needs to remain planar with inappreciable sag in use
5 so that it continues to support the mask uniformly over its entire area.

To insure that the membrane remains sag-free, it is generally the practice to suspend the membrane by a substrate that provides a suitable underlying support
10 grillage, typically consisting of major struts and minor struts (ribs).

Hitherto, for forming the grillage for supporting the membrane that supports the mask coating, a layer of silicon nitrite was deposited over the top surface of a
15 silicon wafer and then the silicon wafer was etched to leave a portion thereof to provide the supporting grillage for the nitride coating that was to serve as the membrane. However, this has proven difficult.

One problem with this approach has been the
20 difficulty of maintaining, during the shaping of the silicon wafer, the mechanical stability of the grillage left to support nitride the membrane. The physical dimensions of commercially available silicon wafers limits formation of thin struts needed.

25 The present invention involves a better way to prepare a mask useful in electron beam lithography.
Summary of the Invention

In a first aspect the invention is a method for forming a mask assembly for use in lithography. The
30 method comprises the steps of: forming a support structure that comprises a substrate that includes a plurality of windows filled with a temporary fill; forming over the filled-windowed substrate a mask; and removing the temporary fill.

35 In a second aspect the present invention is a method for forming a mask assembly for use in lithography. The method comprises the steps of: forming a support structure that comprises a substrate that includes a

plurality of windows filled with a temporary fill; forming over the filled-windowed substrate a membrane layer for supporting the mask layer; forming a mask layer over the membrane layer; and removing the temporary fill.

5 In a third aspect the invention is a method of forming a mask assembly that comprises the steps of: forming in a substrate a support structure, which includes major and minor struts that define an array of windows in a two-dimensional array of rows and columns, 10 by successive rounds of cutting in the substrate a fraction of the total window area to be formed; filling such fraction of windows with temporary fill before the succeeding round of cutting and filling until all the window areas are cut and filled; forming a membrane layer over a top surface of the support structure; forming a mask layer over the membrane layer; and removing the fill 15 from the windows.

20 In a fourth aspect the present invention is a method of forming a mask assembly for use in electron beam lithography that comprises the steps of: forming in a substrate a first set of spaced-apart windows; filling the windows with a temporary fill; forming in the substrate a second set of windows in the spaces between the first set of windows for forming with the first set a 25 two-dimensional array of windows arranged in row and columns; filling the second set of windows with a temporary fill; depositing over the filled-windowed substrate a layer suitable for supporting a mask; depositing over the last-mentioned layer a layer suitable 30 for providing a mask; patterning the last-mentioned layer to form a mask, and removing the temporary fill from the windows, whereby the mask layer is free of underlying substrate.

35 In a fifth aspect the present invention is a method for forming a mask assembly comprising the steps of: forming by use of a mold a support structure that defines an array of windows arranged in rows and columns; filling the openings with a temporary fill; forming over the

support structure a membrane layer; forming over the membrane layer a patterned mask; and removing the temporary fill.

5 In a sixth aspect the invention is a method of forming a mask support structure that comprises the steps of: forming in a substrate a first set of spaced apart windows; filling the first set of windows with a temporary fill; forming in the substrate a second set of windows located in portions of the substrate between the 10 first set of filled windows; and filling the second set of windows with a temporary fill.

15 In a seventh aspect the invention is a method of forming a mask support structure that comprises the steps of: placing in a mold which is shaped to facilitate the formation of a support structure a plurality of parallel minor struts; and forming in the mold a mask support structure that comprises a frame and plurality of major struts that are orthogonal and attached to the minor struts with the major and minor struts defining a 20 plurality of windows arranged in a two dimensional array of rows and columns.

From a product aspect, the invention is the product of the various methods described.

25 The invention will be better understood from the following more detailed description in conjunction with the accompanying drawing and claims.

Brief Description of the Drawing

30 FIG. 1. shows a top view of a mask support structure in accordance with the invention suitable for use in electron beam lithography;

FIG. 2 shows a cross-sectional view taken along a dashed line 2-2 of FIG. 1 with a membrane layer over the mask support structure;

35 FIGS. 3, 4, 5, and 6 show steps in the fabrication of the mask support structure of FIG. 1;

FIG. 7 shows a cross sectional view taken along a dashed line 7-7 of FIG. 6;

FIG. 8 shows the section of FIG. 7 after there has

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been deposited a membrane over a top surface thereof;

FIG. 9 shows the section of FIG. 8 after there has been deposited over the membrane a layer that will be patterned to serve as the mask for electron-beam
5 lithography;

FIG. 10 shows the section of FIG. 8 after the fill has been removed from the windows;

FIGS. 11-14 show cross sectional views that illustrate an alternative method for providing the
10 membrane and mask layers over a mask support structure of the kind shown in FIG. 7; and

FIGS. 15, 16, and 17 show a top view, a first cross-sectional view through a dashed line 51-51 of FIG. 15, and a second cross-sectional view through a dashed line 52-52 of FIG. 15 of a mold useful in the production
15 of a mask support structure in accordance with another embodiment of the invention;

FIG. 18 shows the resulting mask support structure after it is removed from the mold;

FIG. 19 shows a three-dimensional view of a mask support structure in an early stage of fabrication in accordance with another embodiment of the present invention;

FIG. 20 shows the mask support structure of FIG. 19 at a succeeding stage of fabrication; and

FIG. 21 shows a cross-sectional view taken along a dashed line 2-2 of FIG. 1 with a stencil mask over the mask support structure;

The drawings are not necessarily to scale.

30 Detailed Description of the Invention

Referring now to FIGS. 1 and 2, there is shown a mask support structure 10 for use in electron beam-lithography in accordance with the invention with FIG. 1 showing a top view and FIG. 2 showing a cross-sectioned view through a dashed line 2-2 of FIG. 1. Mask support structure 10 comprises a substrate 12 having an outer frame portion 12a, advantageously of square shape, major struts 12b, and minor struts 12c. The outer frame

portion 12a can be any shape, for example, circular. The major struts are vertical regions and the minor struts are horizontal regions. Major struts 12b and minor struts 12c are orthogonal to each other and define a plurality of windows (openings) 18, arranged in an array of rows and columns. The major struts 12b are at least several times thicker than the minor struts 12c.

As seen in the cross-sectioned view of FIG. 2, over a top surface of the mask support structure is a thin membrane layer 20 that is to support a layer (not shown) that will have been patterned to serve as a mask layer. Mask support structure 10 with the membrane layer 20 on top thereof and a patterned mask layer 28 (shown in FIGS. 9-14) over the membrane layer 20 may be denoted as a mask assembly. The mask layer typically is of a material and thickness to scatter electrons to sufficient angles that it intercepts where unpatterned to be useful in electron beam lithography, but allows electrons to pass through the openings in the pattern little impeded. The membrane 20 needs be of a material and thickness adequate to support the mask layer without sagging but to little affect the passage of electrons therethrough.

In accordance with the invention, the mask support structure assembly 10 is prepared in a novel fashion. To this end, as is shown in FIG. 3 there is provided a substrate 12 of a suitable material and advantageously a ceramic, such as aluminum oxide or silicon carbide, of sufficient thickness to be rigid and self supporting, in which are shown by solid lines a first set of windows 18a that are cut in a first round of cutting. In this first round, there are cut one half of the total number of windows to be cut. Advantageously all the windows to be cut are to form a two-dimensional array in rows and columns, as shown in FIG. 1, and in this first round, there are cut alternate windows 18a in each row and column as is denoted by the solid lines. Also shown in FIG. 3 by dashed lines are the regions where windows 18b of the second set that are to be cut in the second round

of cuttings. These will form with the first set 18a the two-dimensional array of windows. In one example the windows 18a and 18b are each about 12 millimeters by 1.1 millimeters, and are formed by laser cutting.

5 After the first set of half of the window pattern
has been cut out to form windows 18a, these windows 18a
are temporarily filled with a suitable material that can
later be conveniently introduced and later conveniently
removed, advantageously an epoxy, silicon oxide, a
10 polymer, or a metal such as aluminum. The result is seen
in FIG. 4 where the first set of filled window regions
18a is shown stippled.

15 Next there are cut out the remaining windows 18b of
the second set, as is shown in FIG. 5, typically in the
same manner as before.

Then the second set of windows 18b are filled typically in the manner used previously to fill the first set. The result is shown in a top view in FIG. 6 and in a cross-sectional view through a dashed line 7-7 of FIG. 6 in FIG. 7. All of the window regions 18a and 18b are shown filled, as is indicated by the stippling in both windows 18a and 18b.

Next, the opposite major surfaces of windowed substrate 12 are ground and polished to provide a mask support structure with smooth, planar, and parallel opposite major surfaces. This can be done, for example, by chemical mechanical polishing (CMP).

As mentioned earlier, there are various ways consistent with the invention in which the membrane layer 20 that will support a mask layer 28 can be provided on the mask support structure 10.

In one method there is deposited, typically by chemical vapor deposition, over a major surface of the mask support structure 10 a layer of the material that will form a membrane layer 20 for supporting the mask layer 28 (shown in FIGS. 9-14), as is shown in the cross-section view of FIG. 8. Suitable membrane materials include silicon nitride, silicon, silicon carbide,

diamond, and aluminum oxide. The membrane should be of a thickness sufficient to adequately support the mask layer but to little impede the passage therethrough of electrons that pass through the patterned mask layer. A thickness of 1000 Angstroms or less should be suitable.

Next, as is shown in the cross-sectional view of FIG. 9, there is deposited over a top surface of the membrane layer 20 a layer that will be patterned to serve as a mask layer 28. The mask layer 28 typically is of a material and thickness to scatter electrons to sufficient angles that it intercepts where unpatterned to be useful in electron beam lithography, but allows electrons to pass through the openings in the pattern little impeded. Examples include tungsten, and tantalum silicon nitride, about 300 Angstroms thick.

Next, the mask layer 28 is patterned appropriately in any suitable manner. Typically this is done by first coating it with a standard electron beam resist, and then patterning the resist coating in the desired mask pattern with an electron beam. Then this mask pattern is transferred in the usual manner from the resist coating into the mask layer 28, after which the resist coating is removed to leave a patterned mask layer 28 as a coating on the membrane.

Now, there is removed the fill material from the windows 18a and 18b to open them. The result is shown in FIG. 10 in which the fill has been removed from the windows 18a and 18b formed between the major and minor struts 12b and 12c and the mask layer 28 has been patterned to serve as a mask. Advantageously the fill material was suitably chosen to permit its easy removal, as by wet chemical etching without damage to the mask. In some instances, it may be possible to remove the fill in the same process used to remove the unneeded portions of the mask layer. In specific cases, the fill may have been removed just before the mask layer was patterned, unless the additional support the fill provides was still needed during the patterning.

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This results in a mask support assembly with a mask layer 28 thereon.

It can be appreciated that a fraction different from one half, for example a third, appropriately chosen to maintain adequate rigidity, of the total number of windows to be cut, can be cut (formed) and filled in separate rounds during the formation of such windows. Additionally, it can be appreciated that rather than a fraction of the total number of windows to be formed can be cut and filled in each round, a fraction of the area of each window to be formed can be instead cut and filled in successive rounds, to maintain the desired strength of the substrate during the window-cutting steps.

As was also mentioned above, various other methods consistent with the invention can be used to provide a membrane layer 20 for supporting the mask layer 28 on the mask support structure 10 shown in FIG. 7. For example, in another method there is prepared a suitable second substrate 30, for example, of silicon, typically of the same size and shape as the substrate 12. As shown in FIG. 11, one major surface of the substrate 30 is covered in turn with an underlying layer of a thickness and material suited for use as the mask layer 28 and an overlying layer of a size and material suitable for use as the membrane layer 20.

Then, as is shown in FIG. 12, the second substrate 30 is bonded by way of its membrane layer 20 to a major surface of the filled-window mask support structure 10 of FIG. 7 by any suitable means, as by plasma activation bonding (not shown) or the use of an adhesive layer (not shown).

Then there is removed the second substrate portion 30, as by etching, to leave the structure shown in FIG. 13, in which mask layer 28 is exposed, supported on the first substrate 12 by way of the membrane layer 20.

There can now be patterned the exposed mask layer 28, in the manner previously described.

There can now be removed the fill in the supporting

grillage to leave the structure shown in FIG. 14, which is the structure desired for mask assembly.

To facilitate the removal of the second substrate 30, it can be ion-implanted before bonding to the mask support structure 10, to form a defect-rich buried layer in its interior. The ions could, for example, be hydrogen or oxygen. This makes it is easy to cleave the substrate 30 along such defect-rich layer. The cleaving of the substrate 30 can appreciably thin the substrate 30 and thus facilitates its subsequent complete removal to expose the layer that is to form the mask layer 28. The dashed line 36 across substrate 30 in FIG. 12 illustrates the location of such an optional ion-implanted layer within substrate 30.

Referring now to FIGS. 15, 16, and 17, there are shown a top view (FIG. 15), a first cross-sectional view (FIG. 16) through a dashed line 16-16 of FIG. 15, and a second cross-sectional view (FIG. 17) through a dashed line 17-17 of FIG. 15 of a mold 50 useful for forming a support structure in accordance with another embodiment of the invention. The mold includes wide openings for defining the major struts and narrower openings (grooves) for defining the minor struts. A plurality of parallel minor struts (elongated strips) 54 have been placed in the grooves of the mold 50. When mold 50 is filled with a molding material, the molding material attaches itself to minor struts 54. Grooves in the mold 50 have a depth (height) of "d" (See FIGS. 16 and 17). Minor struts 54, which typically has a depth less than "d", can optionally be of the same depth (height) d as the grooves in the mold 50. The material for the minor struts 54 and the mold-filling material can be the same or different materials. After the fill material hardens a mask support structure 100 (see FIG. 18) is formed in the mold 50.

FIG. 18 shows the mask support structure 100 after there has been removed from the mold 50. Mask support structure 100 has a frame 56 comprising major struts 56a

and minor struts 54 that define rows and columns of an array of openings (windows) 58. Mask support structure 100 is similar to mask support structure 10 of FIG. 1. It is then advantageously filled with a temporary fill (not shown) and then opposite major surfaces are planarized. Mask support structure 100 is then used as a support for a membrane layer and a mask layer in essentially the same manner as explained previously for support structure 10 of FIG. 1. Still another method of forming a suitable mask support structure for use in the invention is described below with reference to FIGS. 19 and 20.

Referring now to FIG. 19, there is shown a three-dimensional view of a frame 60 which has a plurality of spaced apart large rectangular opening 62 formed therethrough. Only three openings 62 are shown. Frame 60 is useful for forming a support structure in accordance with an other embodiment of the invention. A plurality of parallel grooves 64 are formed that extend across the frame including the regions between openings 62. Grooves 64 can optionally be of the same depth (height) as the openings 62.

Referring now to FIG. 20, a separate minor strut 66 is inserted into each of the grooves 64 to divide the large openings and to form a mask support structure 1000 in accordance with an other embodiment of the invention. Mask support structure 1000 of FIG. 20 is similar to support structure 10 of FIG. 1 and to mask support structure 100 of FIG. 18 and can be used in the manner previously described for such mask support structures. It is then advantageously filled with a temporary fill (not shown) and then opposite major surfaces thereof are planarized. Mask support structure 1000 is then used as a support for a membrane layer and a mask layer in essentially the same manner as explained previously for mask support structure 10 of FIG. 1.

Referring now to FIG. 21, there is shown a cross-sectional view of the mask support structure 10 of FIG. 1

with a stencil mask 21 over a top surface of support structure 10. Stencil mask 21 serves same the purpose as membrane layer 20 (shown in FIG. 2) and the mask layer 28 shown in FIGS. 9-14 and can be substituted for membrane layer 20 and mask layer 28. Stencil mask 21 has formed therethrough a plurality of openings 21a which define a pattern. Stencil mask 21 can be used with the mask support structure 100 of FIG. 18 and with the mask support structure 1000 of FIG. 19.

It can be appreciated that the principles of the invention are essentially independent of the specific materials employed and of the specific dimensions described. For example, subsequent developments in materials and in cutting and filling techniques will likely affect what is preferred in the future. Still further, it should be apparent that in the embodiment involving successive rounds of cutting and filling that it may not be necessary to interleave all of the window opening of different rounds since it should be feasible in some instances to include in the same cutting round pairs or more of adjacent windows of the window pattern desired.

What is Claimed is:

1. A method for forming a mask assembly for use in lithography comprising the steps of:

5 forming a support structure that comprises a substrate that includes a plurality of windows filled with a temporary fill;

forming over the filled-windowed substrate a mask; and

removing the temporary fill.

10 2. The method of claim 1 wherein the mask comprises a membrane layer covered by a mask layer.

3. The method of claim 1 wherein the mask is a stencil mask.

15 4. A method for forming a mask assembly for use in lithography comprising the steps of:

forming a support structure that comprises a substrate that includes a plurality of windows filled with a temporary fill;

20 forming over the filled-windowed substrate a membrane layer for supporting the mask layer; and

forming a mask layer over the membrane layer; and

removing the temporary fill.

25 5. The method of claim 4 in which the support structure is formed by the steps of:

forming in a substrate a first set of spaced apart windows;

filling the first set of windows with a temporary fill;

30 forming in the substrate a second set of windows located in portions of the substrate between the first set of filled windows; and

filling the second set of windows with a temporary fill.

35 6. The method of claim 5 in which the first partial set of windows is approximately one half of the total number of windows to be formed and the second set includes the remaining windows to be filled.

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7. The method of claim 6 in which the windows are in a two dimensional array of rows and columns and in which the first set consists of alternate windows in each row and column.

5 8. A method of forming a mask assembly comprising the steps of:

10 forming in a substrate a support structure, which includes major and minor struts that define an array of windows in a two-dimensional array of rows and columns, by successive rounds of cutting in the substrate a fraction of the total window area to be formed;

15 filling such fraction of windows with temporary fill before the succeeding round of cutting and filling until all the window areas are cut and filled;

15 forming a membrane layer over a top surface of the support structure;

forming a mask layer over the membrane layer; and

removing the fill from the windows.

20 9. The method of claim 8 in which the first round of cutting involves cutting approximately one half of the windows to be cut and a second round involves the remainder.

25 10. The method of claim 9 in which the first round of cutting is of alternate windows in each row and column.

11. The method of claim 4 in which the support structure is formed by the steps of:

30 placing in a mold which is shaped to facilitate the formation of a support structure a plurality of parallel minor struts; and

35 forming in the mold a support structure that comprises a frame and plurality of major struts that are orthogonal and attached to the minor struts with the major and minor struts defining a plurality of windows arranged in a two dimensional array of rows and columns.

12. The method of claim 11 further comprising the step of removing the support structure from the mold.

13. The method of claim 4 in which the forming over the filled-windowed substrate of the membrane and mask layers includes the steps of:

5 forming over a surface of a second substrate in turn a layer suitable for the mask and a layer suitable for the membrane;

bonding the membrane layer of the second substrate to the first-mentioned substrate in a manner to expose the second substrate, and

10 removing selectively the second substrate to expose the mask layer.

14. The method of claim 13 in which the second substrate is first implanted with ions to create in its interior an ion-implanted region and the second substrate is removed in part by cleaving along the ion-implanted region.

15. The method of claim 7 in which the forming over the filled-windowed substrate includes the steps of:

20 forming over a second substrate a mask layer and a membrane layer;

bonding the membrane layer to the filled-windowed substrate and leaving exposed the second substrate;

25 selectively removing the second substrate to expose the mask layer.

16. A method of forming a mask assembly for use in electron beam lithography comprising the steps of:

20 forming in a substrate a first set of spaced-apart windows;

30 filling the windows with a temporary fill;

forming in the substrate a second set of windows in the spaces between the first set of windows for forming with the first set a two-dimensional array of windows arranged in row and columns;

35 filling the second set of windows with a temporary fill;

depositing over the filled-windowed substrate a layer suitable for supporting a mask;

depositing over the last-mentioned layer a layer suitable for providing a mask;

patterning the last-mentioned layer to form a mask, and

removing the temporary fill from the windows, whereby the mask layer is free of underlying substrate.

17. The method of claim 16 in which the substrate is chosen from the group consisting of aluminum oxide and silicon carbide, the membrane is chosen from the group consisting of silicon, silicon nitride, silicon carbide, diamond, and aluminum oxide, and the mask is chosen from the group consisting of tungsten and tantalum silicon nitride.

18. The method of claim 16 in which the major surfaces of the filled-windowed substrate are planarized and made parallel before the deposition of the membrane layer.

19. The method of claim 4 in which the mask support structure is formed by the steps of:

forming in a substrate a set of windows spaced apart by major strut portions of the substrate;

forming a plurality of spaced apart grooves in the major strut portions of the substrate; and

placing one of a plurality of minor strut elongated strips in each of grooves.

20. A method for forming a mask assembly comp

the steps of:
forming by use of a mold a support structure
that defines an array of windows arranged in rows and

columns; filling the openings with a temporary fill; forming over the support structure a membrane layer;

forming over the membrane layer a patterned mask; and

removing the temporary fill.

21. The method of claim 20 wherein the support structure comprises major struts which are orthogonal to

minor struts with the minor struts being placed in the mold prior to forming of the major struts and a frame which supports the major and minor struts.

22. A method of forming a mask support structure
5 comprising the steps of:

forming in a substrate a first set of spaced apart windows;

filling the first set of windows with a temporary fill;

10 forming in the substrate a second set of windows located in portions of the substrate between the first set of filled windows; and

filling the second set of windows with a temporary fill.

15 23. A method of forming a mask support structure comprising the steps of:

placing in a mold which is shaped to facilitate the formation of a support structure a plurality of parallel minor struts;

20 forming in the mold a mask support structure that comprises a frame and plurality of major struts that are orthogonal and attached to the minor struts with the major and minor struts defining a plurality of windows arranged in a two dimensional array of rows and columns;

25 and

filling the windows with a temporary fill.

24. The mask assembly formed by the method of claim

1.

25. The mask assembly formed by the method of claim

30 2.

26. The mask assembly formed by the method of claim

3.

27. The mask assembly formed by the method of claim

4.

28. The mask assembly formed by the method of claim

35 5.

20. The mask assembly formed by the method of claim

6.

00000000000000000000000000000000

30. The mask assembly formed by the method of claim
7.

31. The mask assembly formed by the method of claim
8.

5 32. The mask assembly formed by the method of claim
9.

10. 33. The mask assembly formed by the method of claim
11. 34. The mask assembly formed by the method of claim
12. 35. The mask assembly formed by the method of claim
13. 36. The mask assembly formed by the method of claim
15. 37. The mask assembly formed by the method of claim
14. 38. The mask assembly formed by the method of claim
15. 38. The mask assembly formed by the method of claim
20. 16. 40. The mask assembly formed by the method of claim
17. 41. The mask assembly formed by the method of claim
18. 42. The mask assembly formed by the method of claim
25. 19. 43. The mask assembly formed by the method of claim
20. 44. The mask assembly formed by the method of claim
30. 21 45. The mask support structure formed by the method
of claim 22.

46. The mask support structure formed by the method
of claim 23.

METHODS FOR FABRICATING LITHOGRAPHY APPARATUS

Abstract of the Invention

5 A method for forming a mask assembly for use in lithography, typically electron-beam lithography, first forms in a substrate one half of a plurality of opening therethrough and then fills the openings with a removable fill material. Thereafter are formed the other half of the openings which are then filled with the removable fill material. After all the openings have been formed and filled, a support membrane is formed over the 10 substrate and covers the filled windows. A mask layer is then formed over the membrane and patterned. The fill is then removed from all of the windows.

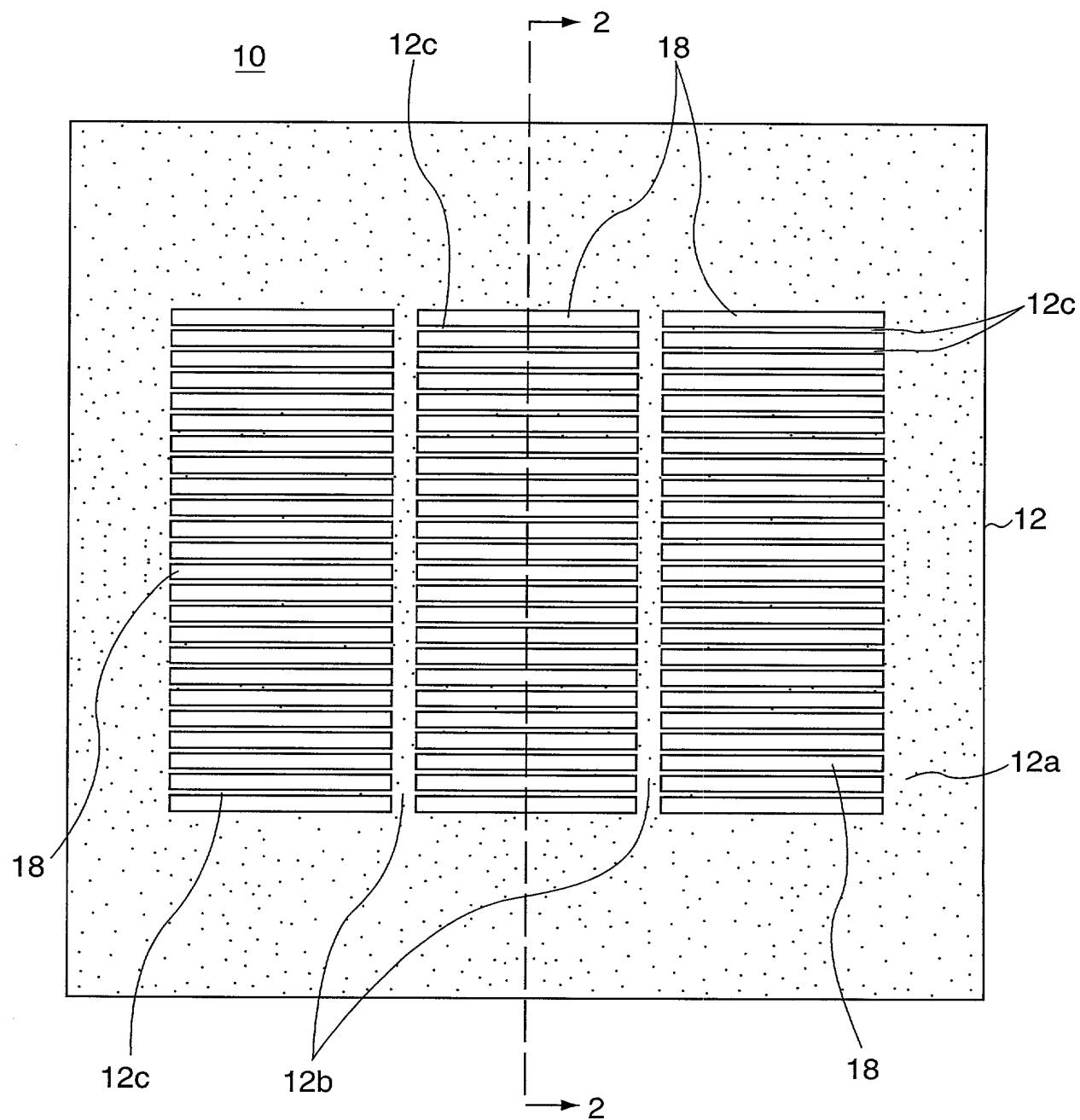


FIG. 1

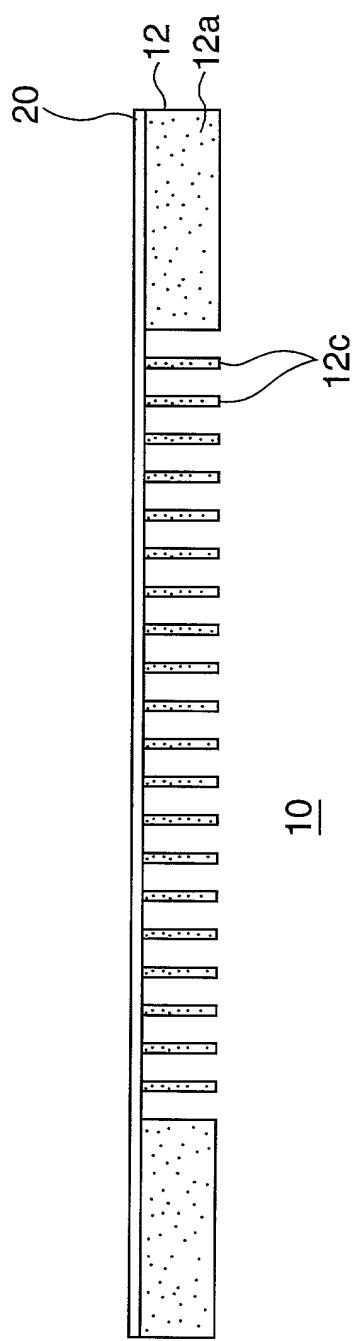


FIG. 2

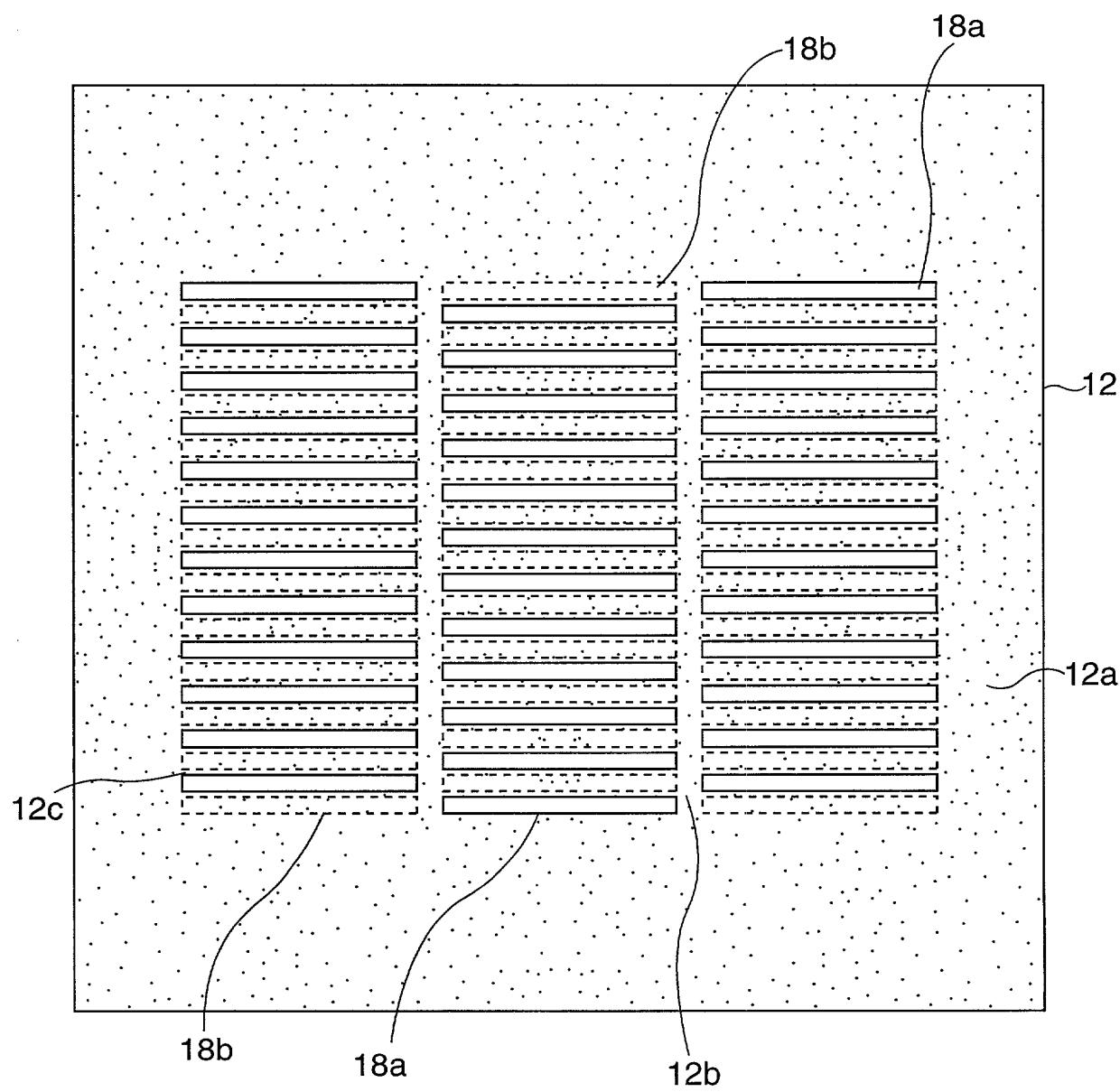


FIG. 3

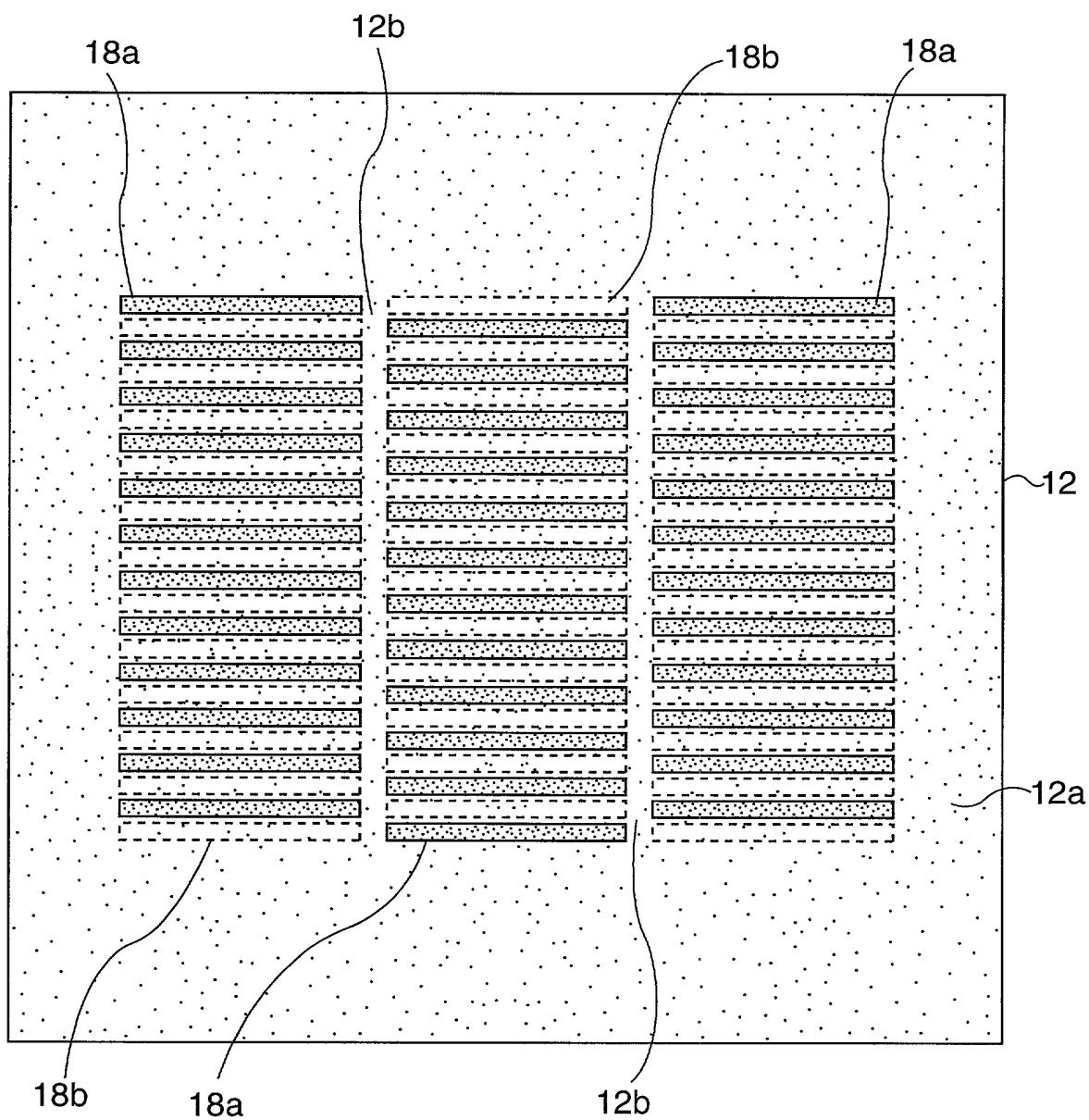


FIG. 4

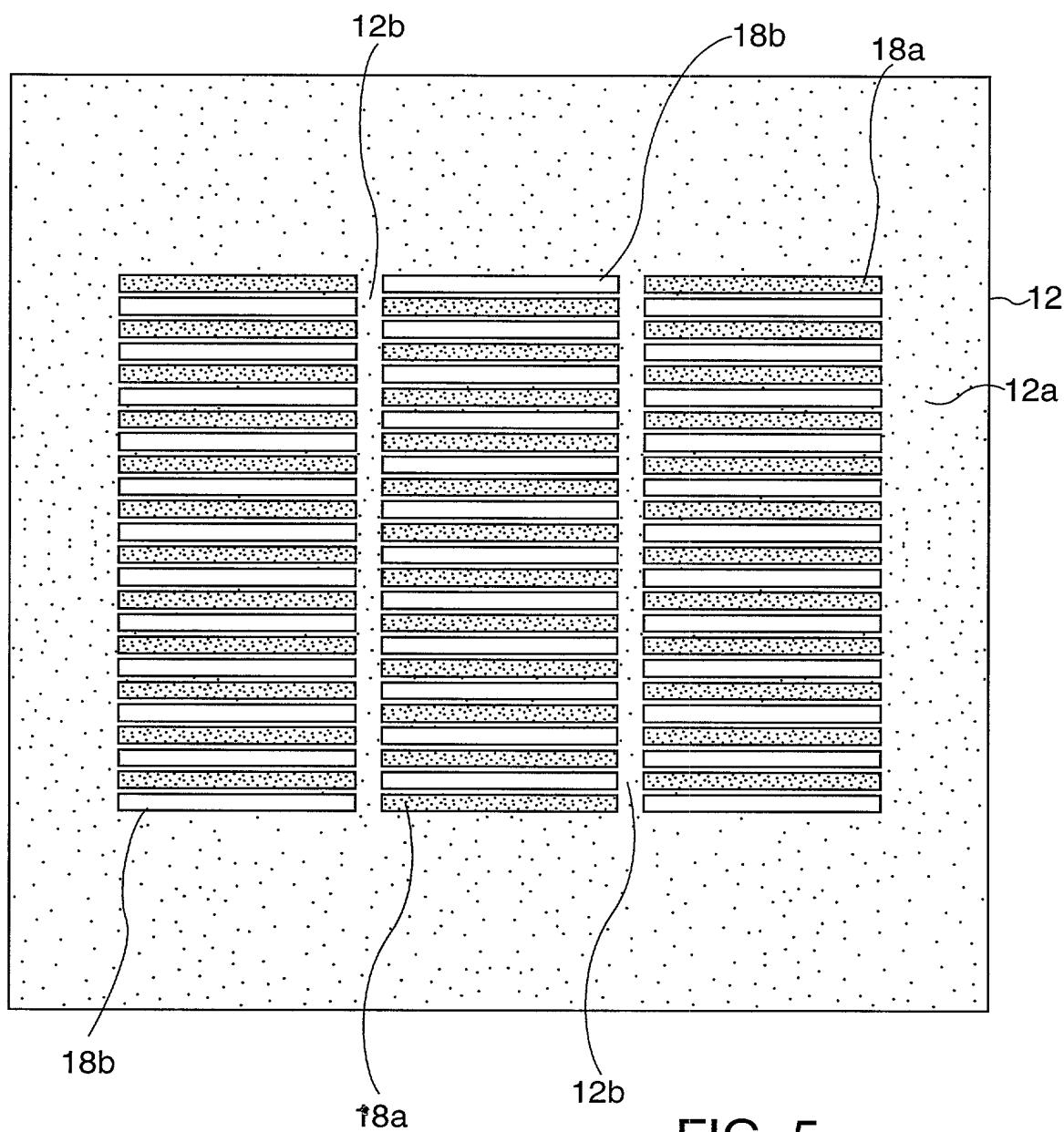


FIG. 5

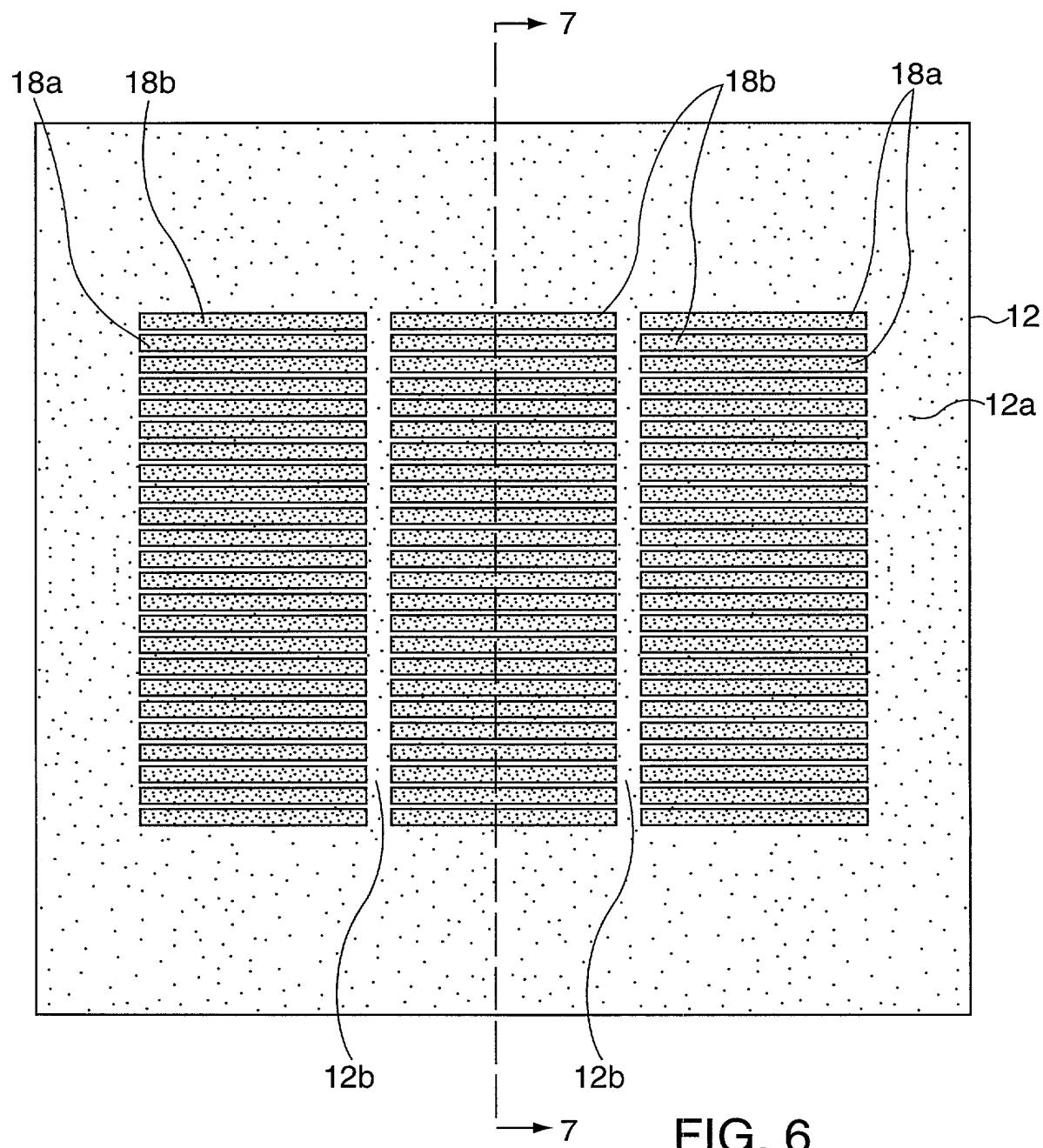


FIG. 6

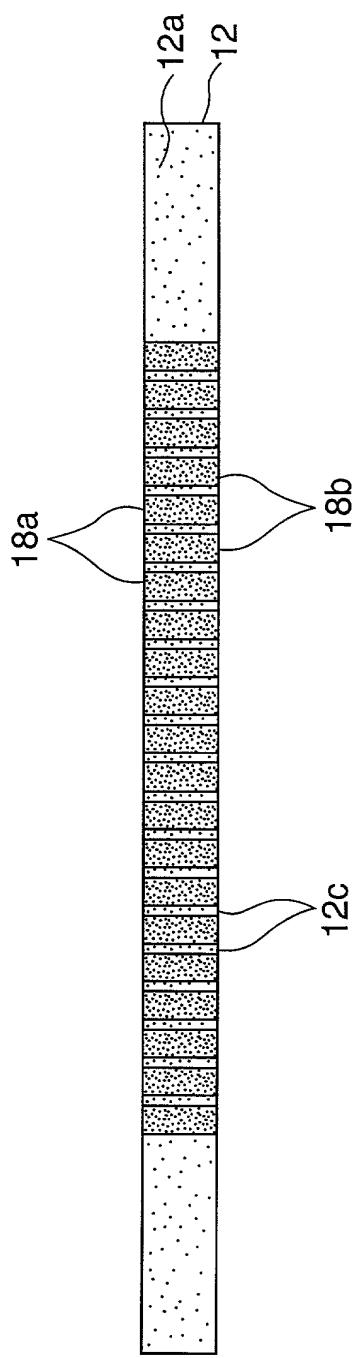


FIG. 7

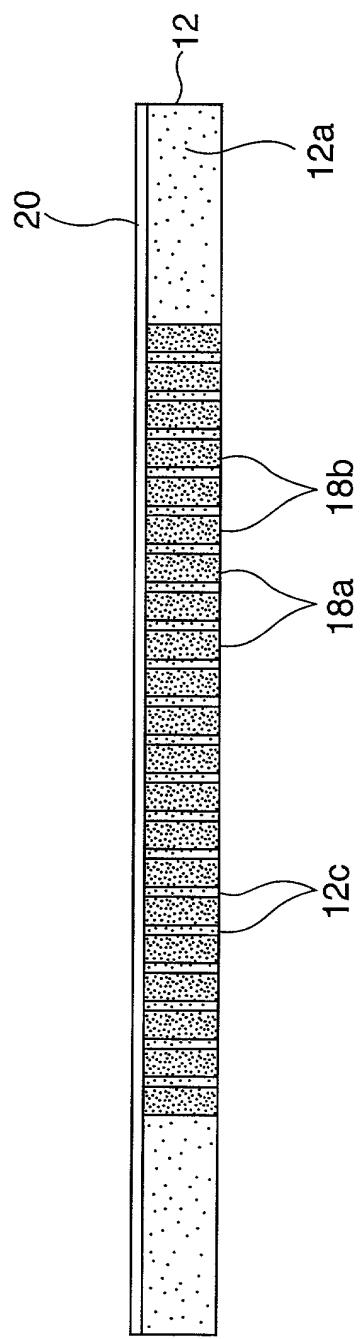


FIG. 8

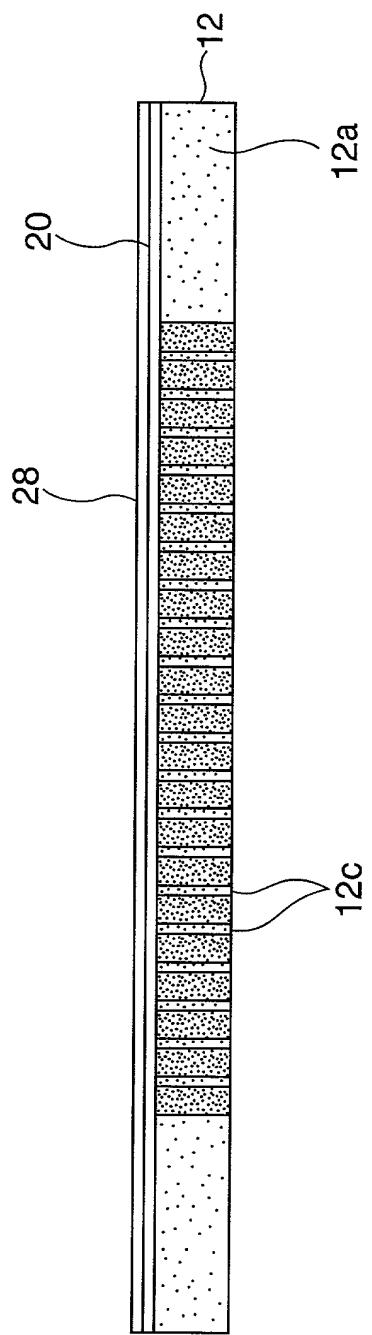


FIG. 9

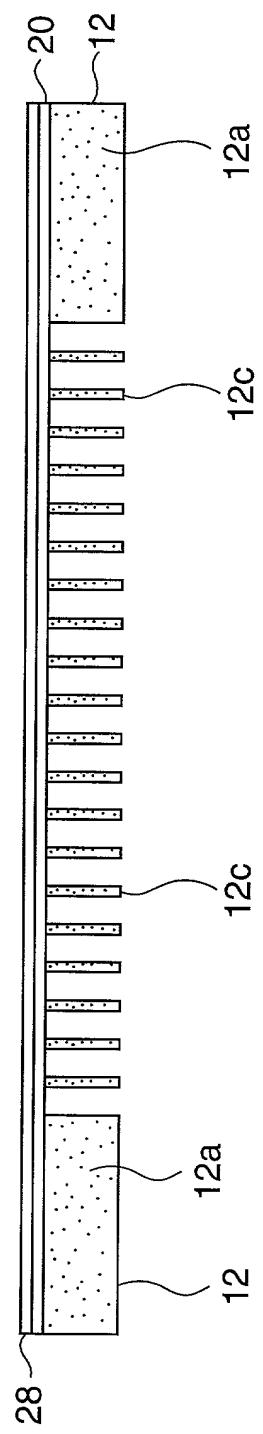


FIG. 10

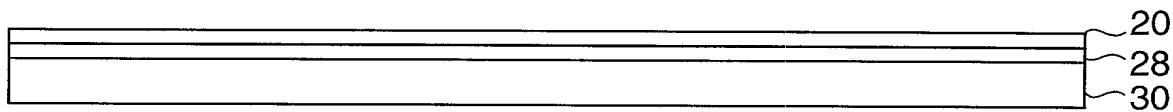


FIG. 11

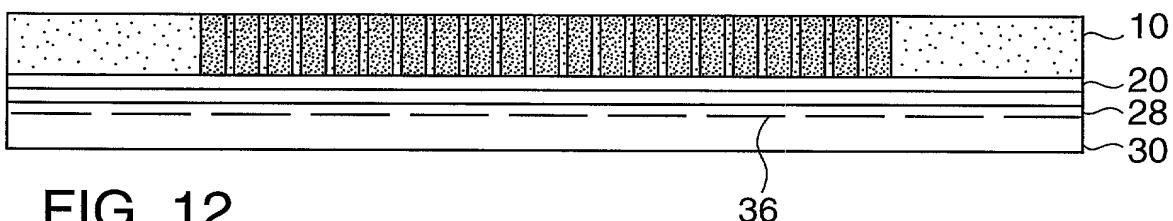


FIG. 12

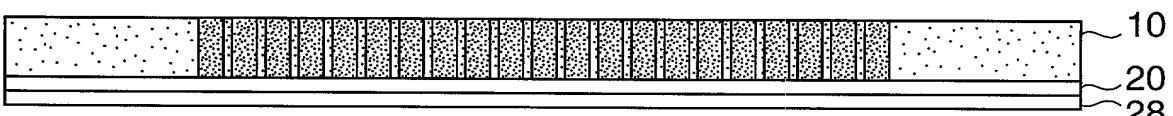


FIG. 13

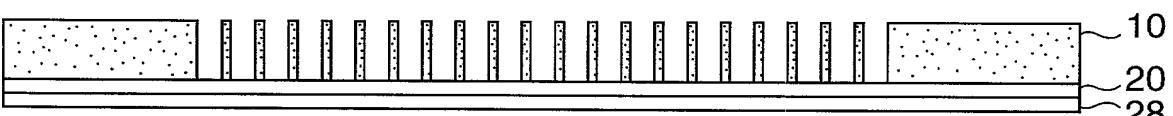


FIG. 14

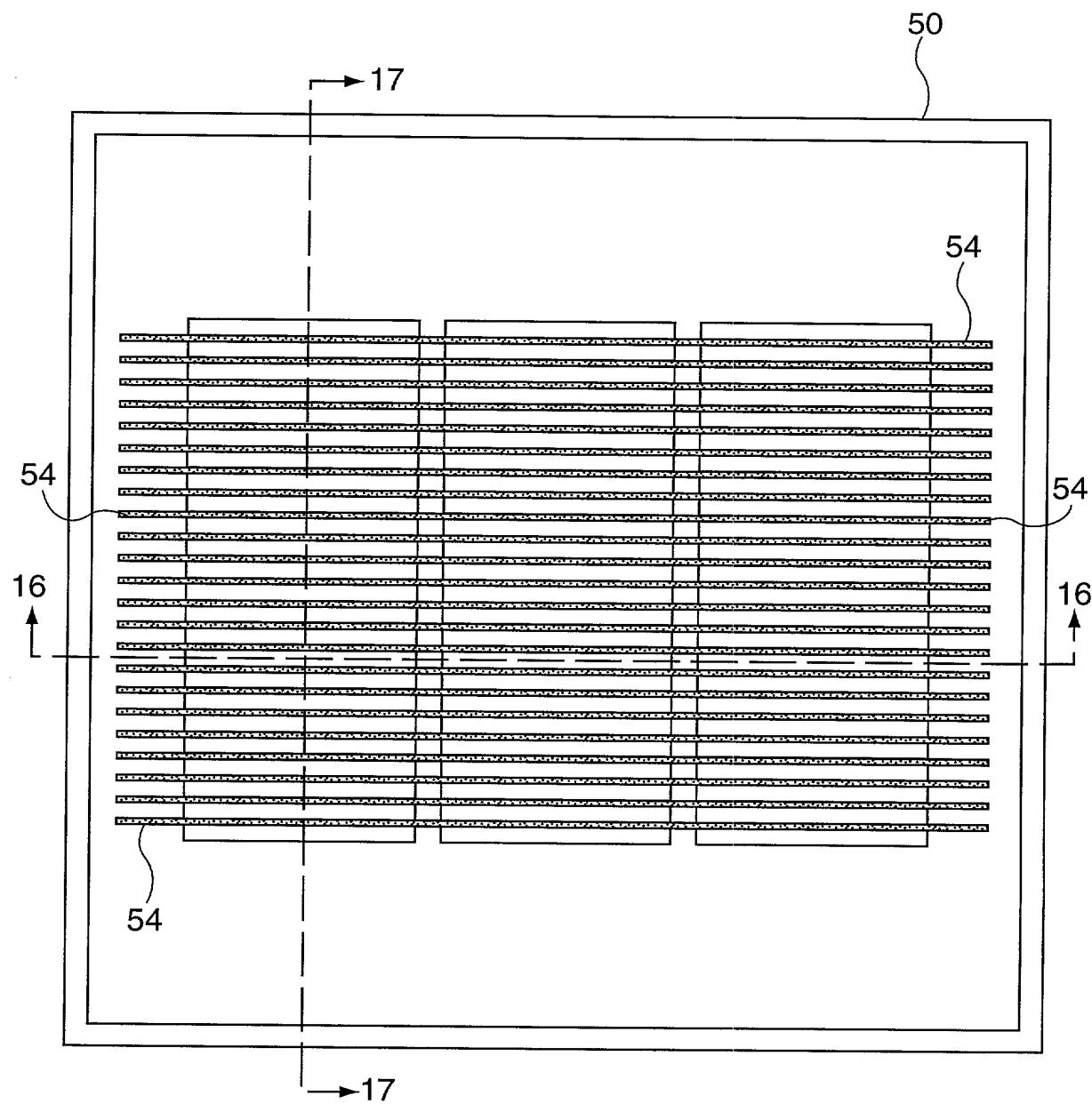


FIG. 15

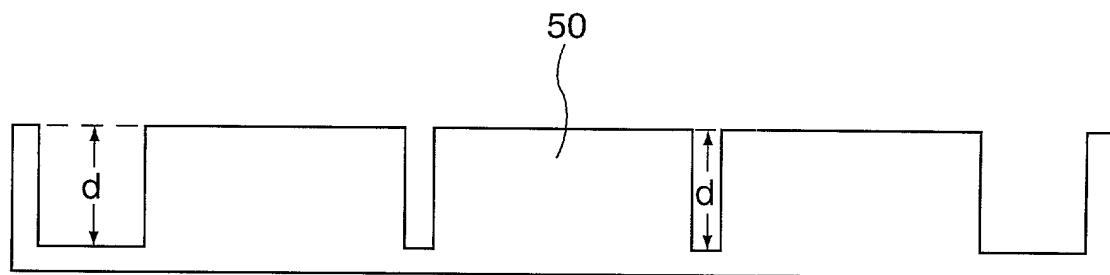


FIG. 16

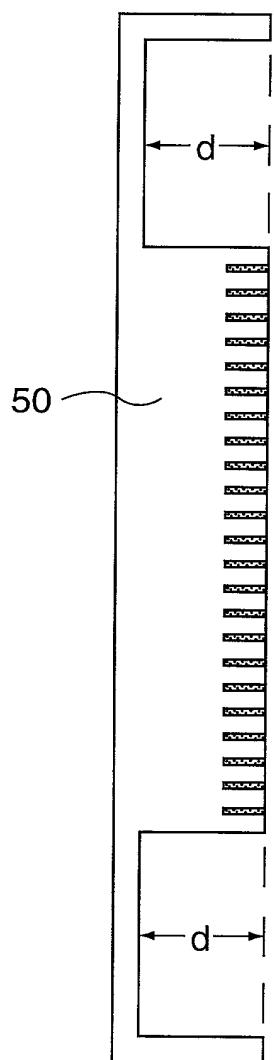


FIG. 17

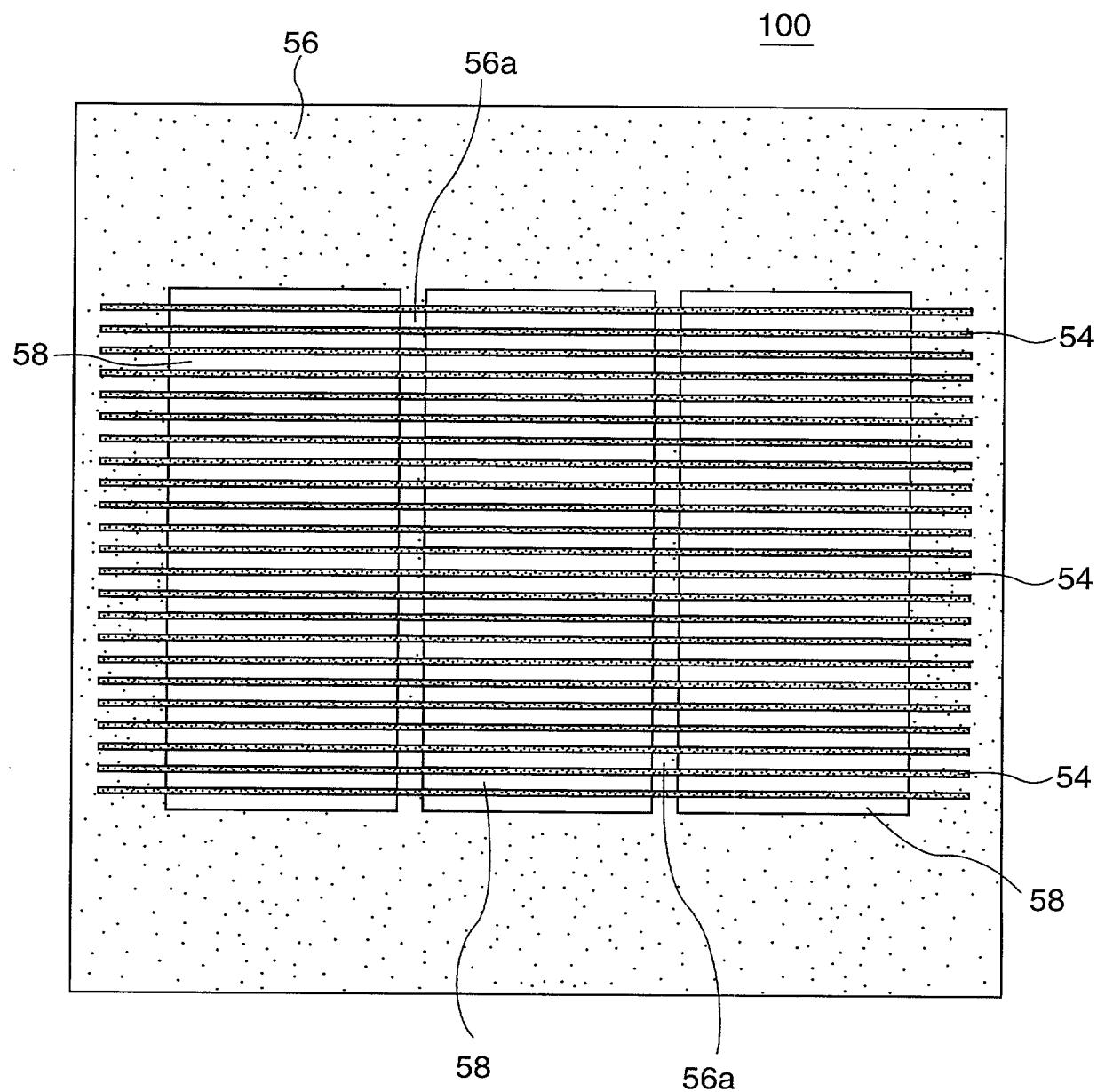


FIG. 18

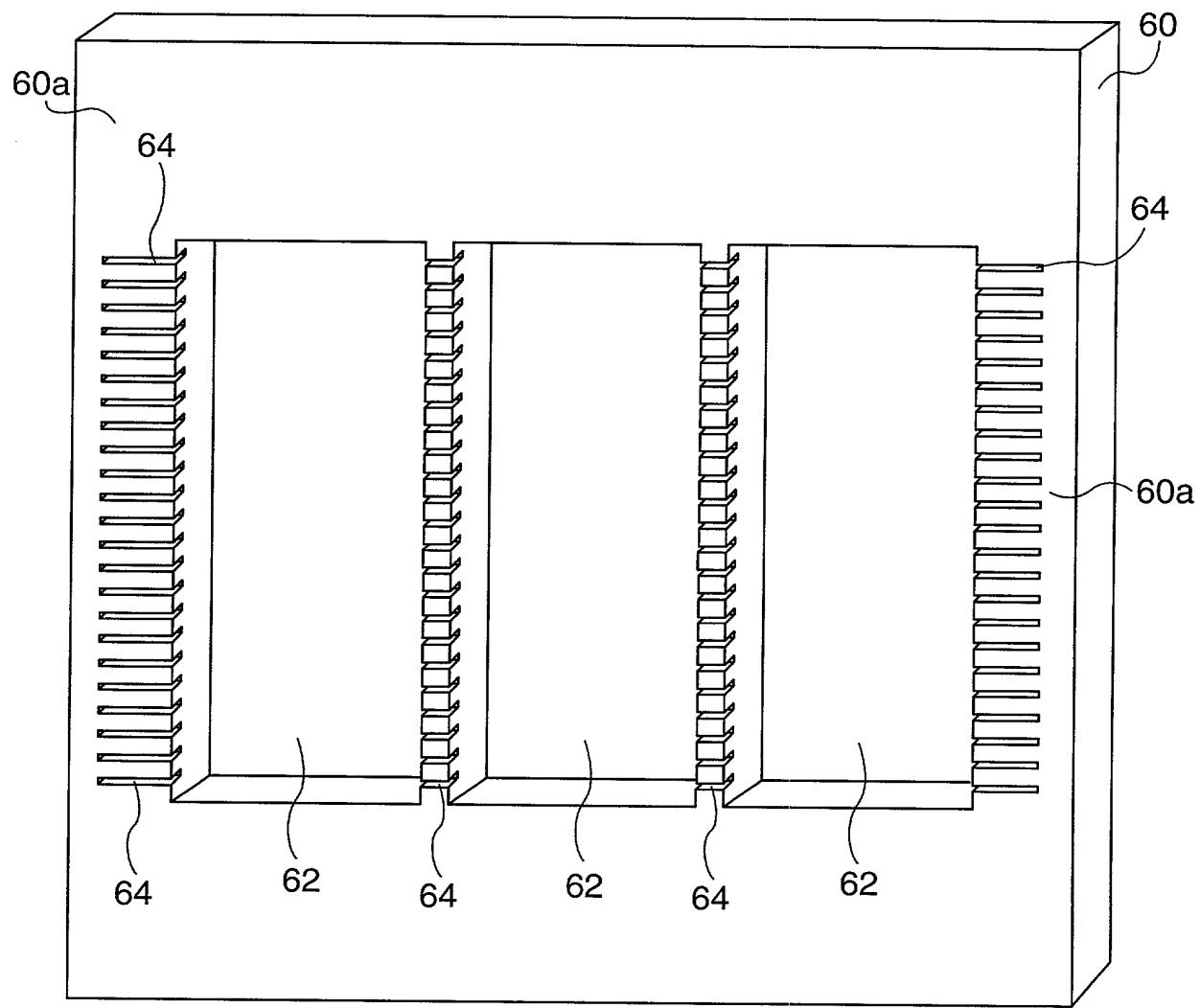


FIG. 19

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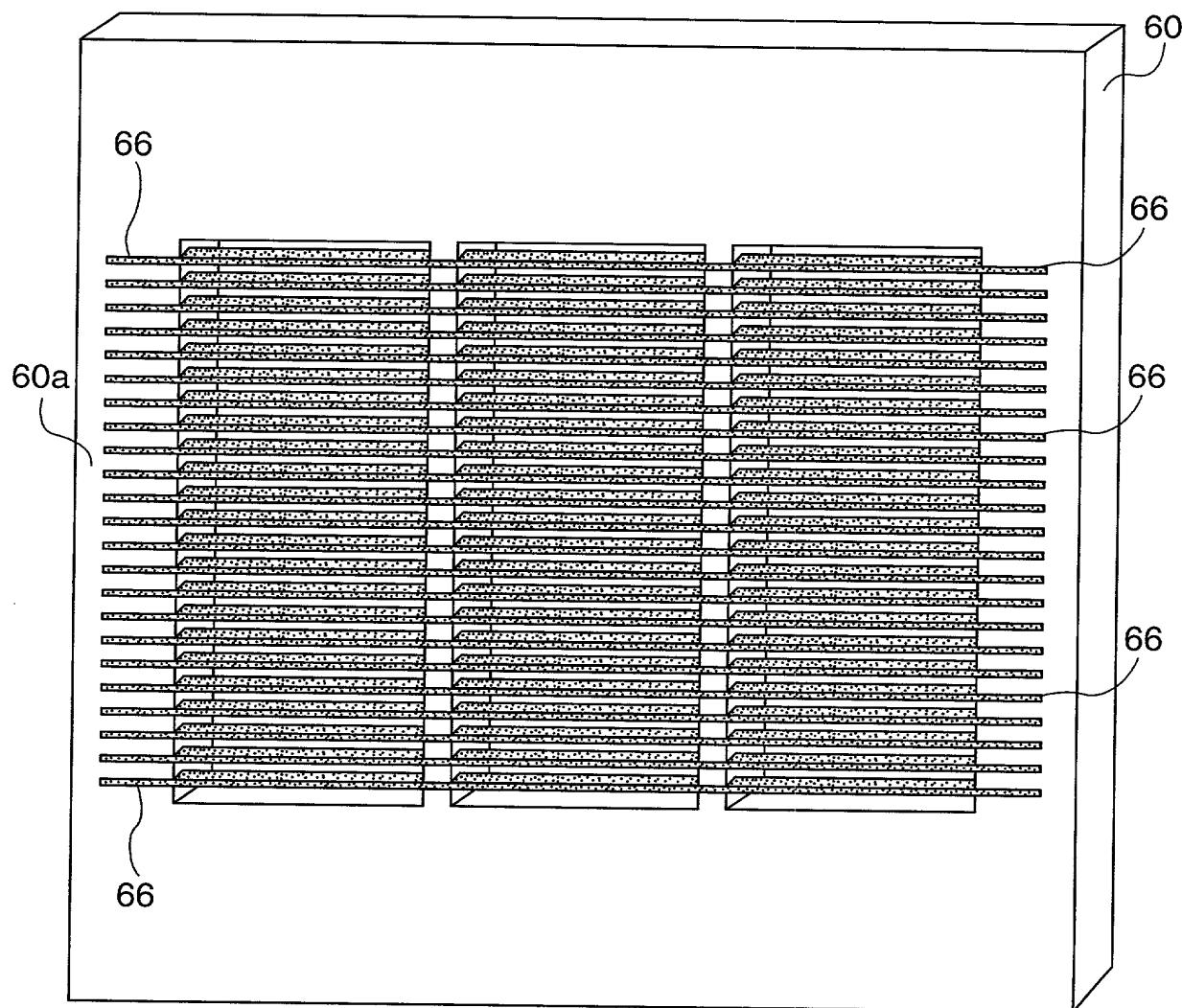


FIG. 20

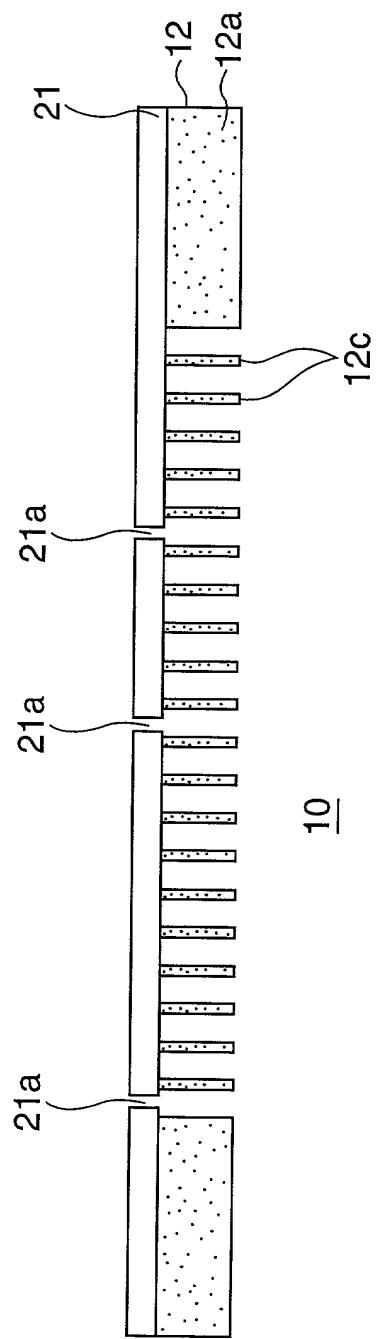


FIG. 21

COMBINED DECLARATION AND POWER OF ATTORNEY
(Utility Patent Application)

As a below named inventor, I hereby declare that:

This declaration is of the following type: original

INVENTORSHIP IDENTIFICATION

My residence, post office address and citizenship are as stated below next to my name. I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below), of the subject matter which is claimed and for which a patent is sought on the invention entitled: METHODS FOR FABRICATING LITHOGRAPHY APPARATUS, denoted as AMAT 5264/5380, the specification of which is attached hereto.

ACKNOWLEDGEMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment specifically referred above.

I acknowledge the duty to disclose information which is material to patentability in accordance with Title 37, Code of Federal Regulations Section 1.56, and which is material to the examination of this application; namely, information where there is a substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent.

PRIORITY CLAIM (35 U.S.C. SECTION 119)

I hereby claim foreign priority benefits under Title 35, US Code, Section 119, of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below, and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

| <u>Application No.</u> | <u>Country</u> | <u>Filing Date</u> | <u>Priority claimed under 35 USC 119</u> |
|------------------------|----------------|--------------------|--|
| NONE | | | |

PRIORITY CLAIM (35 U.S.C. Section 120)

I hereby claim the benefit under Title 35, United States Code, Section 120, of any United States application(s) or PCT international applications(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose information that is material to the examination of this application, i.e., information where there is substantial likelihood that a reasonable examiner would consider it important in deciding whether to allow the application to issue as a patent) which occurred between the filing date of the prior application(s) and the national or PCT filing date of this application.

| <u>Application Serial No.</u> | <u>Filing Date</u> | <u>Patented</u> | <u>Pending</u> | <u>Abandoned</u> | <u>Status</u> |
|-------------------------------|--------------------|-----------------|----------------|------------------|---------------|
| NONE | | | | | |

POWER OF ATTORNEY

I/We hereby appoint the following attorneys and/or agents to prosecute this application and transact all business in the US patent and trademark office connected therewith: Irwin Ostroff (Reg. No. 26,013), Edward P. Brandeau (Reg. No. 17,789), Michael L. Sherrard (Reg. No. 28,041), Peter J. Sgarbossa (Reg. No. 25,610), Donald Verplancken (Reg. No. 33,217), Lawrence Edleman (Reg. No. 25,225), Michael B. Einschlag (Reg. No. 29,301), Joseph Bach (Reg. No. 37,771), Raymond Kam-On Kwong (Reg. No. 37,165), James C. Wilson (Reg. No. 35,412), Sally Brashears (Reg. No. 38,087), and Robert W. Mulcally (Reg. No. 25,436).

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DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Date: October 25, 2000

Signature: Cheng

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